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EXPERIMENTAL STUDY OF PERFORMANCE AND EMISSION CHARACTERISTICS OF A SINGLE CYLINDER DIESEL ENGINE USING KARANJA BIODIESEL AND DIESEL BLENDS

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ABSTRACT

The primary source for propulsion in many vehicles is an internal combustion engine. The biggest challenge for engineers is to meet the current emission norm. Injection pressure, injection timing, combustion chamber geometry, climatic conditions, swirl rate are the factors which influence in direct injection diesel engine characteristics. The electronic fuel injection system is the advanced technology which uses high pressure fuel system and accurate timing of fuel injection controlled by electronics. In this work the study of properties of fuel and mechanical and electronic injection system are done. This experiment is done in 5HP, single cylinder direct injection diesel engine with a constant speed of 1500rpm. The mechanical spring loaded injector and electronic fuel injector is used to perform the test. In this work karanja oil methyl ester is blended with diesel based on volume fraction 20% of karanja with 80% of diesel. Performance and emissions are compared by using mechanical injection system. Adavnced electronic fuel injection system is replaced the mechanical injection system and the comparison is done.

KEYWORDS: Engine, Fuel System, Swirl Rate & Speed

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Original Article

INTRODUCTION

Automobile is also a part of life of many people in this world. Diesel is one of the vital fuels being used in vehicles for passenger vehicle and heavy transportations. The internal combustion engine with direct injection is widely used recently for vehicle with diesel fuel. Emission from automobile is also one of the main cause of global warming. The health of people is also under concern because of air pollution caused by vehicle emission. The government is making strict emission norms BS4 to BS6 for regulating the emission. The oil refineries are demanded to produce fuel which satisfying those norms. Diesel is getting depleted day by day. Though there are many suggested alternative fuel like Hydrogen, Vegetable oil, Biodiesel, CNG etc. Each one has its own merits and demerits. India is focusing on the use of biodiesel to reduce the diesel consumption. Environment Protection Agency (EPA) of United States states that engine could be used for fuel blend upto 20% of biodiesel without ant modification. The information on website of Hindustan petroleum reports, India's National Mission on Bio-diesel also targets on usage of 20% biodiesel blend on vehicles running on Indian roads. India supports biodiesel production from non-edible plant seeds like Jatropa, Karanja, and Mahua etc. The following content gives brief

information about diesel and alternate fuels.

Daming Huang et al[1] had reviewed the recent developments of Biodiesel and its characteristics, processing and economics of Biodiesel industry. Parag Saxena et al[2] had reviewed the properties of biodiesel and blends of biodiesel‖ stated the continuous increasing demand for energy and the decreasing petroleum resources. For each property, various models have been proposed, which are specific to the type of feed oil. Shashikant Vilas Ghadge et al[3] had stated, the high FFA (19%) level of crude mahua oil can be reduced to less than 1% in a 2-step pre-treatment process of esterification using acid catalyzed (1% v/v H_2SO_4) reaction with methanol (0.30–0.35 v/v) at 60^oC temperature and 1-hour reaction time. After every step, a time of minimum 1 hour is required for removal of methanol– water mixture. The next step product having acid value less than 2mg KOH/g is used for the final alkali–catalyzed (0.7% w/v KOH) trans-esterification reaction with methanol (0.25 v/v) to produce biodiesel. USV Prasad et al[4] had investigated the effect of fuel injector nozzle hole diameter and injection pressure. BSFC increases for larger nozzle hole diameter. With respect to injection pressure, BSFC and emissions gets decreased upto 210bar injection pressure except NO_X emission.

In this work karanja biodiesel is selected based upon the oxygen content, solubility in diesel fuel, flash point, stability and fuel properties such as viscosity and cetane number. Though there are many biodiesels close to diesel properties, the reason for choosing karanja is the economic impact it has over the other biodiesel resources through its tree's products and by-products. K20 diesel 80 blend is chosen

BIODIESEL PRODUCTION

According to ―AUTO FUEL VISION AND POLICY 2025"of India, among the total petroleum energy requirement of India around 81% is met by diesel. In 2016 the energy demand of diesel is expected to raise upto 85.5% and in 2025 its raise is expected to be around 140 % of present diesel demand. Production of biodiesel from vegetable oil and ethanol from transesterification process are considered as the best substitute of diesel in the country. There are lot of waste degraded land available which can be used to increase the resource, produce oil and its conversion to biodiesel.

Availability of Karanja Oil

Total production (annual million tonne MT) of pongamia oil = 55000 tonnes / year

Seed production [T/ha]	= 7 to 9
% total availability (MT)	= 1.75 to 2.25
Oil recovery (% of seed)	= 25
Cost (Rs/ton of oil)	= 2588
Cost per litre	= 10.50 Rs for karanja methyl ester
Cost per litre	= 18 Rs for karanja

Study of Fuel Properties

Table 1: Properties of Fuel

properties	unit	Karanja biodiesel	diesel
Density	gm/cc	0.860	0.824
Calorific value	Kcal/Kg	3700	4285
Cetane number	-	41.7	49
Flash point	^{0}C	161	56
Fire point	^{0}C	189	63
Kinematic viscosity at 40 ^{0}C	cSt	5.12	3.05

EXPERIMENTAL SETUP & PROCEDURE

Table 2: Engine Specification

Engine Manufacturer	Kirloskar Oil Engines Ltd
Bore	80 mm
Stroke	110mm
Number of cylinders	1
Compression ratio	16.5:1
Speed	1500 rpm
Swept volume	553 cm^3
Clearance volume	36.87 cm^3
Fuel injection timing	23^0 BTDC
Method of cooling	Water Cooled

Figure 1: AVL Smoke Meter and DI Gas Emission Analyser

Experiment Procedure

First we have done the test with diesel in the single cylinder 4 stroke direct injection CI engine using mechanical injector. Then we have done the test with karanja diesel blend with mechanical injector. After that we have done the test by using electronic fuel injector with diesel. Then we have done the test with karanja diesel blend with electronic fuel injector. Comparison of all the results was done. For each load the time for fuel consumption and corresponding emission values are recorded. The performance of engine like BTE & BSEC is calculated from the fuel consumption time with the spring loaded fuel injector.

PERFORMANCE AND EMISSION CHARACTERISTICS USING EFI

Comparison with Electronic Fuel Injection System

Performance Characteristics

Brake Thermal Efficiency

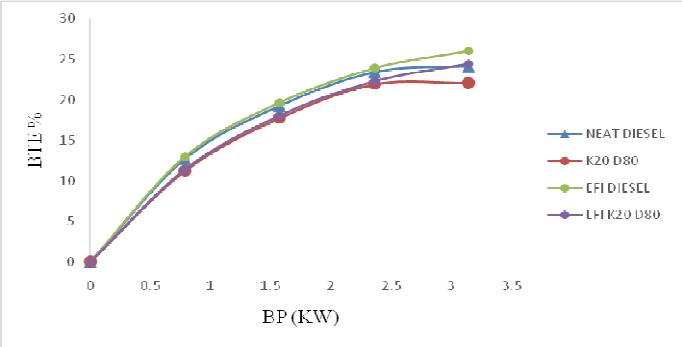

Figure 2: Comparison of BTE with BP

The figure 2 shows the BTE at various loads of diesel and karanja oil methyl ester blends. Graph shows the efficiency of diesel is higher than biodiesel because of the density of the blend is higher which causes increased time for evaporation of fuel droplet. The BTE increases 1.92% for EFI diesel and 1.67% for EFI B20 compared with mechanical injection system.

Brake Specific Fuel Consumption

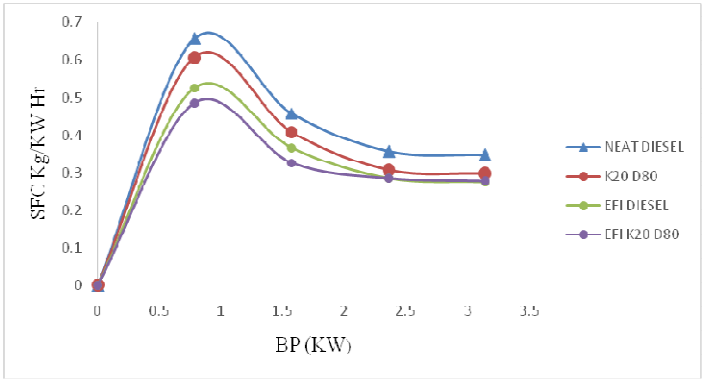

Figure 3: Comparison of BSFC with BP

Graph shows the comparison of bSFC with BP. The figure 3 shows that the bSFC of diesel is lower than the biodiesel blends due to its calorific value. bSFC with EFI system decreases 20% for both diesel and B20 blend compared with mechanical fuel injection system.

Emission Characteristics

Hydro Carbon Emission

Figure 4 shows that at peak load HC emission with EFI B20 is 21.57% less than B20 with mechanical injector. As load increases HC emission increases.

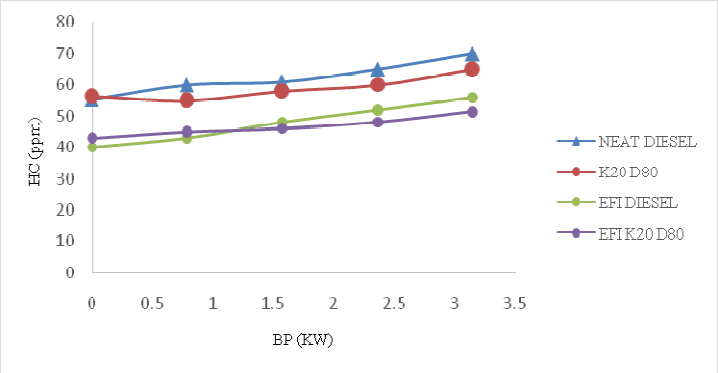

Figure 4: Comparison of HC with BP

Carbon Monoxide Emission

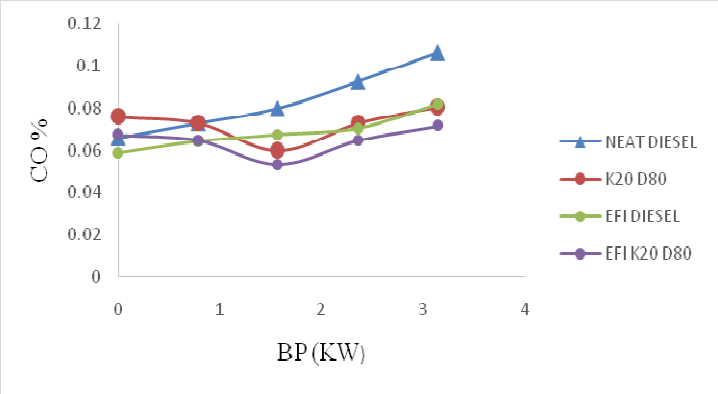

Figure 5: Comparison of CO with BP

Biodiesel blends are giving less CO emissions than diesel because of its high oxygen content. Figure 5 shows that CO emission is 11.9 % lower for diesel and 11.25 % lower for B20 blend with EFI system.

Oxides of Nitrogen

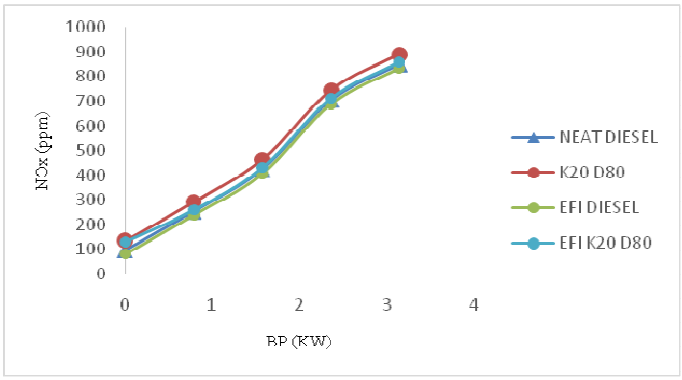

Figure 6: Comparison of NOx with BP

Figure 6 shows that k20D80 is giving higher NOx but with EFI K20D80 is giving less NOx. NOx emission is higher for blends.

The EFI B20 shows 3.61% increase in NOx than engine with mechanical system.

Smoke Emission

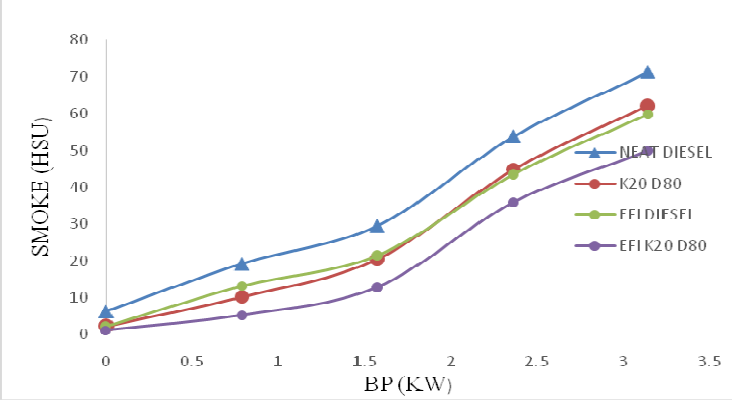

Figure 7: Comparison of Smoke with BP

The heterogeneous combustion mixture in CI engine results in different air fuel ratio at different places inside the combustion chamber. The rich mixture is formed in the region near the nozzle and in the inner core of the droplet. Due to high temperature in absence of oxygen the fuel undergoes pyrolysis to form smoke. The sulphur content which results in PM emission is absent in biodiesel. Thus the smoke emission from the biodiesel is less compared to diesel. The advanced fuel injection system plays a major role in reducing the smoke emission in the vehicle exhaust. The reduced droplet size of injected fuel reduces the soot formation resulting in less smoke emission for EFI compared to diesel. The figure 7 shows the reduction of 20% reduction in smoke for EFI B20 than mechanical injector whereas EFI diesel shows 16% reduction in smoke.

CONCLUSIONS

Following conclusions are made based on the report of experimental investigation carried out on single cylinder direct injection diesel engine

- Performance characteristics of the biodiesel blend with diesel are lower than diesel due do its lower calorific value. The blend B20 shows reasonable thermal efficiency which is 0.92% less compared to diesel. Hence B20 can be considered as suitable blend.
- The high pressure electronic fuel injection system shows better improvement in performance and emission characteristics of the engine considered for study. The diesel fuel with EFI system shows 1.92% and 20% improvement in BTE and BSFC respectively
- The emissions from engine with EFI system reduces 11.9%, 18.5%, 15.2% of CO, HC and smoke respectively compared to diesel with conventional injection system. Similarly the amount of HC, CO, NOx and smoke gets lowered for B20 with electronic fuel injection system. The reduction of HC, CO, NOx and Smoke in exhaust is 21.57%, 11.25%, 3.61% and 20.56% respectively.
- The NOx emission for diesel fuelled engine is higher for high pressured electronic fuel injection system. The B20 blend injected with EFI system shows 3.91% increase in NOx. Due to lower ignition delay and reduced premixed combustion phase NOx emission from biodiesel and its blends are lower than diesel in both fuel injection systems.

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